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ABSTRACT

METHCDS FOR DETERMINING TEACHING LOAD MEASUREMENTS AND FOR PROJECTING BUILDING SPACE NEEDS FOR THE VARIOUS FUNCTIONAL ACTIVITIES OF THE UNIVERSITY CF MINNESOTA ARE DISCUSSED AND EVALUATED. FACTORS WHICH MIGHT INFLUENCE THE SPACE NEEDS OF THE INDIVIDUAL DEPARTMENTS ARE IDENTIFIED AND EVALUATED. ASSIGNABLE SQUARE FOOT BUILDING SPACE NEEDS ARE PROJECTED IN LARGE AGGREGATES. (FS)

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A New Projection of

BUILDING SPACE NEEDS AT THE UNIVERSITY OF MINNESOTA

BY THE YEAR 1975

Based on Methods Developed in the 1956 Study

Second Edition August, 1967

Vernon L. Ausen

Office of Room Assignments and Scheduling

Office of Admissions and Records, University of Minnesota

June, 1964

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A NEW PROJECTION OF BUILDING SPACE NEEDS AT THE UNIVERSITY OF MINNESOTA BASED ON METHODS DEVELOPED IN 1956

INTRODUCTION

The Minnesota Legislative Interim Commission on State Building Needs was established in 1955 to study the building needs of state institutions during the ensuing decade. The University cooperated in the above study, projecting its building space and land needs to the year 1970 and translating the added space needs into particular building units. This was the University's first comprehensive long-range building program.

The methods developed to estimate long-range building needs were subsequently published by William T. Middlebrook.(1) It was expected that the square foot projections might eventually become outmoded as a byproduct of the dynamics of education, but that the methods would nevertheless lend themselves to new projections based on a changing situation. They might also be used to determine the physical facilities implications of predetermined educational configurations. Moreover, the projection method, if properly used, would facilitate central administrative understanding and control to avoid the hazards of uneconomic and disorganized expansion.(2) It is important, therefore, to discern the nature of this new planning and administrative tool.

In view of college attendance forecasts and already inadequate physical facilities, building space planning was seen in 1956 to be a continuing and important aspect of educational planning. Planning methods were needed which would include qualitative as well as quantitative evaluations because student populations, teaching methods, subject matter fields, and techniques of research not only differed between colleges, but were in a constant state of change. In addition they had to reflect over-all guidelines of University educational policy, serving as a general framework within which the room needs of the respective departments, independently calculated, could be evaluated, modified and programmed, and periodically reviewed thereafter. Finally, they had to be adaptable to changes in educational emphasis.

The methods used permitted identification and evaluation of the various factors which might ultimately influence the space needs of the individual departments. They were applied to a number of dissimilar colleges, each having its own student population and also offering courses to students from other colleges. Some colleges were primarily involved with laboratory or clinical teaching, whereas others relied heavily on lectures and recitations. The teaching load was calculated in such a way that the impact of such differences on space needs could be accurately measured and properly credited. It was determined that in some cases the most relevant measure of teaching load is "student station hours" of teaching. This

(1) Middlebrook, W. T., How to Estimate the Building Needs of a College or University, University of Minnesota Press, 1958.
(2) Ibid, page 3.

allowed for the fact that some students take lighter work loads than others, and that students taking laboratory courses use the rooms more hours than students taking lecture courses. Experience with this method confirms the premise that the sum total of hours that students spend in classrooms and laboratories is a sound basis for computing teaching loads and instructional building space needs to accommodate those loads. Nevertheless, it is evident that space needs for some activities are more closely related to the number of "bodies" served than to their involvement on campus in terms of time. In the case of research and graduate training space, this measurement is confined to the "number of graduate students."

Certain basic information is essential to these methods of projecting building space needs. First, one must know how many students will be registered in each college, both on the undergraduate and graduate levels; the colleges in which those students will be taking courses; and the scheduled hours of laboratory or lecture work involved in each college. One must also know what space use standards are acceptable. With that information at hand, the methods can be used to project building area needs in an equitable manner as the appropriate loads increase.

The methods for determining load measurements and for projecting building space needs for the various functional activities of the University are discussed and evaluated in the chapters which follow. Refinements have been introduced into the original method where experience and further study justify changes in the procedures. However, the basic approach and procedures introduced in 1956 have been found to be adequate and satisfactory. It must be kept in mind that these methods project assignable square foot building space needs in large aggregates instead of the precise square foot needs of a particular department of any college.

STUDENT ATTENDANCE AND TEACHING LOADS

Overall enrolment trends described in the original projection have proven to be reasonably reliable. It was forecast that enrolment would climb from 23,393 in the Fall Quarter, 1955, to 31,800, 38,900 and 47,000 by 1960, 1965 and 1970 respectively. Official attendance for the Fall Quarter, 1962, was 33,616. However, attendance data in the individual colleges have not followed the forecasts as closely as have total University attendance figures. The most serious departure has been in the Graduate School, where attendance in 1962 already exceeded that predicted for 1970. The Dean of Admissions and Records made new attendance forecasts available for this study, using 1975 as the target date. They are shown in Table I.

Various techniques involved in forecasting attendance have been described in Mr. Middlebrook's book, and need not be repeated here.(3) The 1956 study also contained data identifying by college the number of students taking lower division work and the number taking advanced, professional, and graduate work. That breakdown was not used and comparable data is therefore not included in this report. It is expected, however, that a junior college program involving the metropolitan area will influence the proportion of lower division to upper division-graduate students sometime after 1970, and factors used in the new projections take this into account.

(3) Ibid, pages 15-22

TABLE I: STUDENT ATTENDANCE FIGURES FOR FALL QUARTER

(Net Number of Students in Attendance at End of Second Week)

College	1947(a)	1954(b)	Projected 1960(c)	1963	Projected 1970(c)	Used for 1975(d)
AFHE	1,872	1,213	1,820	1,870	2,835	3,500
Business	1,566	614	1,000	620	1,800	1,000
Dentistry:	349	433	500	455	750	550
Dentistry						(450)
Dental Hyg						(100)
Duluth	1,432	1,657	2,800	3,178	4,000	6,000
Education	1,656	1,983	3,300	2,533	4,500	4,700
General	1,887	1,634	3,400	3,255	6,000	4,250
Law	728	358	500	512	775	1,050
Liberal Arts	8,645	5,428	8,500	11,133	12,000	16,250
Medical Sciences:	1,397	1,052	1,215	1,238	1,450	1,600
Medicine						(615)
Pub Health						(250)
OT-PT						(150)
Nursing						(420)
MedT						(165)
Morris				690		2,000
Pharmacy	371	145	300	225	500	400
Technology	5,283	2,577	4,500	3,177	7,000	6,000
University College	170	62	75	46	150	200
Veterinary	24	184	190	163	240	300
	(25,380)	(17,340)	(28,100)	(29,095)	(42,000)	(47,800)
Graduate	2,373	2,416	3,100(e)	5,368	4,400(e)	13,200(f)
	559	643	600	649	600	750
	28,312	20,399	31,800	35,112	47,000	61,750

(a) The year following the first year of the post World War II enrolment bulge.
(b) Base period for original projection of long range building needs.
(c) See W. T. Middlebrook, How to Estimate the Building Needs of a College or University, page 20.
(d) Based on forecasts from Dean R. E. Summers.
(e) Those on Minneapolis and St. Paul Campuses were projected at 3053 in 1960 and 4268 in 1970 (Middlebrook, page 20).
(f) Of these, 13,000 will be on the Minneapolis and St. Paul Campuses.

TABLE II: HOURS PER WEEK THAT A STUDENT SPENDS IN CLASSROOMS

COLLEGE IN WHICH THE

College Giving The Courses	AFHE	BA	Dentistry		Duluth	Educ	GC	Law	Lib Arts
			Dent	DHyg					
AFHE	11.9					.1			
Bus Admin	.1	8.9				.1	.2	.2	.4
Dentistry			12.4						
Dent Hyg				8.9					
Duluth					15.5				
Education	.7					5.1			.1
General College	.4			.8		.2	13.2		
Law								15.0	
Liberal Arts	3.3	4.6		5.7		5.1	1.1	.6	11.6
Medical Sciences:									
Medicine	.3		8.7	4.4		.1			.1
Med Tech									
Nursing						.2			
Physical Med									
Pub Health	.3		.2	1.2		.5			.2
Morris									
Mort Science									
Pharmacy									
Technology	2.4	.4				.5	.7	.1	3.1
Vet Medicine									
ROTC	.1						.1	.1	.2
Total Hours	19.5	13.9	21.5b	21.0b	15.5	12.9bc	15.5	16.0	15.7

a Based on the twelve academic quarters from fall 1956 through spring 1960. from fall 1957 through spring 1959.
b Does not include hours spent in the clinics.
c Does not include hours involved with practice teaching.
d Students on the Morris Campus exceeded this figure through the Spring
e Primarily work taken in general purpose classrooms. (Laboratories used rather than instructional)

AND LABORATORIES OF EACH INSTRUCTIONAL UNIT[a]

STUDENT IS REGISTERED

Medical Sciences											
Med	MedT	Nurs	OT-PT	PubH	Morris	Mort	Pharm	Tech	UC	Vet	Grad
				.1				.1	2.2	.5	.8
						.5	.9	.2	2.1		.2
		.1	.2	.5					.4		.9
		.6				2.2			.1		
									.1		
	2.4	1.0	1.1	2.8		4.3	3.5	2.9	8.7		2.7
17.4	7.4	3.6	3.2	.4			2.5			1.7	.7
	2.8										
		6.3		.2							
.3			12.7								
.9		.7		11.8		.6	.4		.2		.2
					16.0						
						9.5					
							13.3				
	.5			.2		1.8	3.6	16.2	1.5		1.4
										24.6	
						.1	.3	.3	.2	.3	
18.6[b]	13.1[b]	12.3[b]	17.2	16.0	16.0[d]	19.0	24.5	19.7	15.5	27.1[b]	6.9[e]

Data for Business Administration is for fall 1958 through spring 1960. Data for Law

Quarter of 1963, but are not expected to after four years of work are available.
for scheduled graduate courses only are classified as graduate research training

The original study identified the number of class hours of scheduled instruction which each student, on an average, receives from the college in which he is registered and from each other college of the University. These data are commonly referred to as the "college crossover" figures because they indicate the extent to which students go outside their own college to take courses offered by another college. By reflecting the extent of "service" teaching by each college, they make possible the projection of overall building space requirements for the total teaching load of each college. Obviously, space needs of a college can be greater even though its own enrolment remains stable if its"service" load for students from other colleges is increasing.

Reorganization of academic disciplines, changes in curriculum and degree requirements, introduction of new courses, etc., will influence college crossover figures. Consequently, a new study was made, averaging registration data over twelve consecutive quarters starting with the fall of 1960 so that the crossover data used in this study will reflect the current situation rather than that of the early 1950's.(4) The new crossover data are summarized in Table II. This second study distinguishes between clinical and laboratory hours where applicable. Clinical space needs are based on numbers of students rather than on student station hours of teaching, as in the 1956 study. The data reflect organizational structure existing in the spring of 1964.

The 1975 teaching load of each college, computed by relating the data in Table I to that in Table II, follows. Appendix A details this data by college of enrolment.

TABLE III: TEACHING LOADS BY COLLEGE IN 1975

College	Total Student Station Hours	Laboratory Station Hours
AFHE	53,735	20,957
Business Administration	21.960	658
Dentistry	5,580	3,515
Dental Hygiene	890	837
Duluth	93,000	21,390
Education	40,092	10,424
General College	59,232	2,369
Law	15,770	
Liberal Arts	297,376	41,633
Medical Sciences		
Medical Technology	462	
Medicine	32,124	9,637
Nursing	3,636	364
OT-PT	2,090	1,087
Public Health	13,578	950
Morris	32,000	7,360
Pharmacy	5,320	2,288
Technology	182,328	34,642
Veterinary Medicine	7,380	4,059

(4) Study initiated by Wayne Quist, and completed by James Crewe.

THE BASIC APPROACH IN PROJECTING BUILDING SPACE NEEDS

The initial projection of building space needs to 1970 used 1954 space as a base, and added to that amount an increment which would provide for the additional teaching, research and service loads expected by 1970. This assumed that building space was adequate for the load at that time. Where this was obviously not so, an adjusted base figure was used in the calculation.

As the first step, assignable square feet of each category of building space in 1954 were divided by the load appropriate to the category to determine how many square feet of space were used in the base period for each unit of that load. This was called the space use factor. As then conceived, a space use factor could be calculated for any year for which figures on space use and related loads are available. It merely indicated what existed at any particular time.

A space use factor was considered to be an optimal space use factor if accepted standards of space use were being met at the same time. This was seen as a point of equilibrium, where efficiency of use avoided both overcrowding on the one hand and wastefulness on the other. When the space use factor reflected such a situation, it could be viewed as a standard in itself, being a composite of particular space use standards.

The amount of additional space needed was determined by adding a specified amount of space for each added unit of load. This measurement was called the space increase factor. The space increase factor would equal the optimal space use factor if an equilibrium had been reached between overcrowding and wastefulness. In the earlier study, however, there was an underlying assumption that space then in use for each category was essentially required, even if not fully utilized.(5) In such instances, the space increase factor was smaller than the optimal space use factor because the level of optimal efficiency had not been reached.

The formula used to determine how much space was needed to accommodate a projected load for any particular category of use was:

$$Y = a + c\,(x - b)$$

where a was total existing building space, x was the projected load, b was the existing load, c was the space increase factor and Y was total building space need.

It is apparent that that formula carried forward existing inequities in space assignments, except when a was adjusted to correct the most obvious examples of overcrowding (or of wastefulness). This meant that if space was inefficiently used in the base period, a level of optimal overall efficiency would never be reached, other things remaining equal. That objection can be overcome by adjusting base period space use by the formula:

$$Y' = a\left(\frac{c}{d}\right) + c(x - b)$$

where d is the existing space use factor and Y' is total optimal building

(5) Middlebrook, page 25.

space needs. Because it emphasizes optimal efficiency rather than the status quo, the latter approach will be used in this study. Moreover, c will be the optimal space use factor, and replace the space increase factor in the formula, which may then be shortened to:

$$Y = cx$$

where c is the optimal space use factor and x is the projected load.

FACULTY OFFICES

Faculty offices were greatly overcrowded in some departments in 1956, whereas other departments had more office space than needed. On the premise that basic office requirements were essentially the same for each college, an optimal space use factor was obtained by multiplying standard square foot areas by the number of full time and part time faculty in each college and dividing the product by the college's teaching load.(6) The resulting optimal space use factor became the space increase factors for faculty offices. Inasmuch as those figures were based on space use standards, they are applied in this study also, using the formula Y = cx to obtain faculty office space needs for the respective colleges in 1975.

Optimal space use factors for faculty offices will change as the considerations on which office needs are based change. The student-faculty ratio, for example, will influence these factors. Because a higher ratio is possible for undergraduate than for graduate students and since total student station hours include graduate lecture courses, an increase in the graduate proportion of total station hours reflects a greater proportion of faculty to students. A continuing trend in that direction would tend to make the optimal space use factors for faculty offices progressively inadequate. Attendance forecasts for 1975 indicate that this will be the case. The change anticipated in ratio of undergraduate-professional students to graduate students between the years 1961 and 1975 is shown in Table IV.(7) Note that the ratios are predicated on a college distribution of the forecasted 13,000 graduate students on the Minneapolis and St. Paul Campuses developed by the Office of Room Assignments and Scheduling.(8)

TABLE IV: RATIO OF UNDERGRADUATE-PROFESSIONAL TO GRADUATE STUDENTS

College	1961	1975
AFHE	4.7 : 1	3.4 : 1
Business Administration	2.0	1.1
Dentistry	19.5	7.1
Education	4.0	2.6
Liberal Arts	7.0	3.6
Medical Sciences	2.0	1.0
Pharmacy	8.2	5.5
Technology	3.7	2.1
Veterinary Medicine	3.0	2.6

(6) Middlebrook, Page 30
(7) Memorandum from V. L. Ausen to L. J. Pickrel, May 28, 1964
(8) See Appendix A.

Optimal space use factors for offices used in the 1956 study have been increased from zero to .3 square feet per student station hour in consideration of the extent to which the ratio of undergraduate-professional to graduate students is expected to increase between 1961 and 1975. No adjustment was made for Dentistry, Medicine, and Veterinary Medicine since the student to staff ratios in those professional schools already approximate those for the Graduate School. The figure for ROTC was increased to reflect a situation unique to those units. Table V shows the extent of the increases.

The standard used for office areas will also influence optimal space use factors. The standard in the 1956 study was 120 square feet for each faculty person on a full time appointment and 75 square feet for each half time assistant. A new comprehensive standard of 130 square feet per full time equivalent faculty person is used in this study. This will provide a private office of nine by fourteen feet. A model office of those dimensions was constructed in the Architecture Court in 1963 for faculty inspection and comment. Subsequently, an ad hoc faculty committee reporting to the Advisory Committee on Space Allocation and Use recommended that the figure of 130 square feet be continued as the standard area for a basic faculty office.(9) Inasmuch as the new standard is roughly equivalent to the combined standards used in 1956, any influence that it might have in altering optimal space use factors is considered negligible.

TABLE V: OPTIMAL SQUARE FEET OF FACULTY OFFICE SPACE PER STUDENT STATION HOUR OF TEACHING IN EACH COLLEGE

College	Based on 1956 Study	Revised For 1975
AFHE	1.0 sq.ft.	1.0 sq.ft.
Business Administration	.5	.8
Dentistry	.8	.8
Duluth	.5	.5
Education	.6	.8
General	.4	.4
Law	.4	.5
Liberal Arts	.6	.7
Medical Sciences	.8	.8
Morris		.5
Pharmacy	.7	.7
ROTC	.4	1.0
Technology	.8	.9
Veterinary Medicine	.9	1.0

(9) The report of the Ad Hoc Committee is appended to the minutes of the Advisory Committee for Space Allocation and Use for September 12, 1963.

Application of the above optimal space use factors results in the additional space needs for faculty offices seen in Table VI. Part of the area shown is required to make up for existing deficiencies, and part is required as a result of added teaching loads. ROTC is omitted because it does not now appear that the program offered in 1975 will require additional office space.

TABLE VI: FACULTY OFFICE SPACE REQUIREMENTS IN 1975

College	Total Student Station Hours 1975	Area Per SSH (Sq.Ft.)	Total Area (Sq.Ft.)
AFHE	53,735	1.0	53,735
Business Administration	21,960	.8	17,568
Dentistry	6,470	.8	5,176
Duluth	93,000	.5	46,500
Education	40,092	.8	32,074
General	59,232	.4	23,693
Law	15,770	.5	7,885
Liberal Arts	297,376	.7	208,163
Medical Sciences	51,890	.8	41,512
Morris	32,000	.5	16,000
Pharmacy	5,320	.7	3,724
Technology	182,328	.9	164,095
Veterinary Medicine	7,380	1.0	7,380

TEACHING LABORATORIES

The 1956 study assumed that existing teaching laboratories would continue to be used, even if not fully utilized. The space increase factor for laboratories was therefore correlated with laboratory utilization in such a way that the more efficient the use, the greater the increase factor applied to added loads. Experience since 1956 shows that the projections of future teaching laboratory space needs were too high. This would not have happened if the space use factor had been permitted to decrease each successive five year period until a point of optimal efficiency in scheduling was reached at which point the optimal space use factor was established. That approach is followed in this study, and no additional laboratory space is projected until specified laboratory scheduling standards are first met.

The laboratory utilization standards used in the 1956 study were reviewed in light of experience at Minnesota and other institutions of higher learning. Maximum filling or station use, which had ranged from sixty to eighty percent in the earlier study, was established at 75 percent for all colleges. This is the figure used by the four universities in Indiana.(10)

(10) Report by James F. Blakesley, Department of Schedules and Space, Purdue University, at the Workshop Seminar on Planning Physical Facilities for Higher Education held at the University of Wisconsin, June 1964.

The University of Illinois is aiming at 80 percent laboratory utilization on a department by department basis.(11) The latter standard has also been used by the University of California.

Hourly utilization standards are more difficult to derive because the need will vary according to level of teaching and degree of specialization of the laboratory facility. Illinois and Indiana use a standard of 20 hours per week.(12) The Medical and Dental Schools do not appear to be included, however, The California Restudy standard is 24 hours, but the Restudy committee did not consider an average-percentage utilization figure meaningful.(13) "The committee emphasized that except for a few closely related courses, laboratory space cannot be used interchangeably because of its specialized character and other factors. Because most laboratory space is not interchangeable, the committee concluded that each laboratory course had to be studied separately to determine its maximum utilization. It found that the most frequent possible schedule in present laboratories is 24 hours per week, but that numerous laboratories cannot operate successfully, according to faculty testimony, for more than 20, 18, or 12 hours per week." (14)

The 1956 study recognized such differences, but it was believed that an average utilization figure or standard by colleges would be meaningful for purposes of projecting building space needs in general. The standards used ranged from 40 percent to 60 percent hour utilization, which was 17.6 to 26.4 hours per week. These have been re-evaluated in terms of the many factors which influence scheduling, and new standards suggested. The unweighted average approximates 18.85 hours a week when the medical units are excluded. The Restudy committee in California found that the weighted mean of maximum schedules for individual laboratories to be 20.7 hours per week as compared to the Restudy standard of 24 hours. Table VII lists the laboratory hour utilization standards used in this study.

TABLE VII: MAXIMUM HOUR USE EXPECTED PER WEEK FOR EACH TEACHING LABORATORY

College	1956 Study	This Study
AFHE	22	12
Business Administration	26.4	28
Dentistry	26.4	15
Duluth	22	20
Education	26.4	20
General	26.4	30
Liberal Arts	22	20
Medical Sciences	22	12
Morris		20
Pharmacy	17.6	12
Technology	17.6	15
Veterinary Medicine	22	12

(11) Report by Harlan D. Bareither, Director, Central Office on the Use of Space, University of Illinois, at the Wisconsin Workshop Seminar.
(12) Bareither, ibid. Blakesley, op.cit.
(13) Early California "Needs" Restudy, 1955, pages 321-2.
(14) Ibid.

The space use factor will decrease for each college as its laboratory station hour load increases within existing space. When the utilization standards for hour use and station filling are reached, the space use factor at that time will be accepted as the optimal space use factor for the college.(15) Table VIII shows the new optimal space use factors thus calculated for each college, the projected laboratory station hour load, and the resultant assignable square feet of building space required for teaching laboratories in 1975. As in the earlier study, there was an assumption that the proportion of laboratory station hours to total station hours would be the same in 1975 as in 1962.

TABLE VIII: TEACHING LABORATORY SPACE REQUIREMENTS IN 1975

College	Laboratory Student Station Hours 1975	Area Per Lab SSH (Sq. Ft.)	Total Area (Sq.Ft.)
AFHE	20,957	5.0	104,785
Business Administration	658	1.0	658
Dentistry	4,352	2.6	11,315
Duluth	21,390	3.1	66,309
Education	10,424	2.5	26,060
General	2,369	2.4	5,686
Liberal Arts	41,633	2.7	112,409
Medical Sciences	12,038	3.5 (16)	42,133
Morris	7,360	3.1 (17)	22,816
Pharmacy	2,288	4.5	10,296
Technology	34,642	5.7	197,459
Veterinary Medicine	4,059	3.5	14,207

CLINICAL LABORATORIES

The 1956 study included clinical laboratories with other kinds of teaching laboratories, except for the University Hospitals. This distorted the projections because the utilization of clinics is not comparable with that of other laboratories, and cannot be measured in the same terms. In this study, clinical areas are projected separately in terms of square feet per student in the particular college. This factor works satisfactorily when class levels remain proportionate, even though students in some classes may not be involved in clinical instruction.

Only Dentistry and Veterinary Medicine have clinical facilities. Students in Medicine, Physical Therapy, Occupational Therapy, Laboratory Medicine, Nursing and Public Health use the University Hospital facilities.

(15) The calculations appear in Appendix B.
(16) Because of inadequate data, this figure is arbitrary and subject to change.
(17) The calculated optimal space use factor was adjusted to the figure at the Duluth Campus.

The latter are classed as Internal Service inasmuch as the Hospitals operate independently within the College of Medical Sciences and its service load is not necessarily dictated by clinical teaching requirements. Dental Hygiene students use clinical facilities in the School of Dentistry.

The projections for Dentistry and Veterinary Medicine are as follows:

TABLE IX: CLINICAL LABORATORY SPACE REQUIREMENTS IN 1975

	No. Students 1975	Sq. Ft. Per Student	Total Sq.Ft. Required
Dentistry	450	60	27,000
Veterinary Medicine	300	100	30,000

TEACHING SERVICE

The category labeled "teaching service" encompasses departmental rooms associated with teaching, except for faculty offices. Among these are departm tal administrative offices, faculty multi-purpose rooms, preparation rooms, media rooms, storerooms, music practice rooms, laboratories with free hours rather than scheduled class hours, rooms for individual undergraduate student projects with research overtones, and the like. The latter reflects the increasing popularity since the original study was made of individual assignments for advanced undergraduate students. Departments are encouraged to provide separate facilities for this unscheduled work rather than to tie up whole teaching laboratories for use of relatively few advanced students.

The 1956 report projected space needs for "All Other" instructional (or teaching service) space in terms of square feet per laboratory station hour because in many departments most teaching service space related to laboratory instruction. The optimal space use factor used for "All Other" areas in each college had the same proportion to the college's Teaching Laboratory areas in 1970 as in the base period. Since "All Other" areas were conceived as having a fixed relationship with the Teaching Laboratory areas that they support, this relationship could be expressed more meaningfully as a ratio of laboratory service areas to laboratory areas. The latter approach is followed in this study.

Many colleges, however, have few if any laboratories with scheduled classes; as for example, the Law School. In such instances, it is not realistic to relate teaching service needs to the laboratory load. The total student station hour load would be more appropriate. This would be tantamount to relating teaching service space needs to faculty office space needs since the latter are also based on the total student station hour load.

Rather than attempt to base teaching service space projections for some colleges on one basis and for other colleges on another basis, it was decided to develop a ratio of teaching service space to the sum total

of laboratory, clinical laboratory and faculty office space. This seemed logical inasmuch as the amount of space required to serve the faculty and the teaching laboratories depends on the size of the faculty and the number of laboratories in the college. These in turn vary according to the total teaching load and the laboratory teaching load which must be served.

The optimal ratios of teaching service areas to office-laboratory-clinical areas used in this study are somewhat in excess of comparable ratios existing in 1962 for all but three colleges. The most significant increases above the 1962 figure are those for the General College and College of Education. Recent departmentalization in the two colleges and increasing use of unscheduled laboratories in the one college influenced the ratios. Otherwise, increases in the ratios average about ten percent above the 1962 figures. The only appreciable decrease in ratios of teaching service areas to office-laboratory-clinic areas is for the College of Liberal Arts, where the figure for 1975 is only two-thirds that of 1962. This came about because most of the space increases to 1975 for that college are for faculty offices rather than for teaching laboratories.

Table X shows the teaching service space needs for the respective colleges in 1975.

Table X: TEACHING SERVICE SPACE NEEDS IN 1975

College	Sq.Ft. Faculty Office and Clinical-Teaching Lab Needs 1975	Ratio Teaching Service to Office-Lab Space	Total Sq.Ft. Teaching Service Required
AFHE	158,520	.7:1	110,964
Business Administration	18,226	.5:1	9,113
Dentistry	43,491	.4:1	17.396
Duluth	112,809	.6:1	67,685
Education	58,134	.3:1	17,440
General	29,379	.3:1	8,814
Law	7,885	.5:1	3,943
Liberal Arts	320,572	.5:1	160,286
Medical Sciences	83,645	.6:1	50,187
Morris	38,816	.6:1	23,290
Pharmacy	14,020	.6:1	8,412
Technology	361,554	.4:1	144,622
Veterinary Medicine	51,587	.7:1	36,110

GENERAL PURPOSE CLASSROOMS

The optimal space use factor for general purpose classrooms continues to be based on a standard of 30 hours of room use per week and two thirds filling when the classroom is in use. This is daytime use, and is comparable to the hour use standard at the Indiana institutions.(18)

(18) Blakesley, op.cit.

The standard for room filling, however, exceeds the station use figure for those institutions, and is more comparable with the announced standard at the University of California.(19) That standard has not been achieved, however, and California now believes that a figure between 50 percent and 60 percent is perhaps more realistic. (20) A standard of two-thirds filling must, therefore, be considered conservative.

The optimal space use standard of .50 square feet per student station hour on the Minneapolis Campus used in the initial study has proven to be inadequate. In 1962 the space use factors for the Duluth, Minneapolis, Morris, and St. Paul Campuses would have been .63, .65, .57 and .63 square feet per student station hour respectively if the standards for hour use and filling discussed in the above paragraph had been reached. At the same time, the actual square foot of building area per student station ranged from an average of 11.4 on the Morris Campus to 13.1 on the Minneapolis Campus. There is now crowding in some classrooms, and newer facilities using strip benches and case study arrangements involve more area per student. Some teaching aids, such as overhead projectors, also require more space at the front of the classroom.

The Indiana institutions are using a standard of 15 square feet per station on the average, and this appears to be a more realistic figure in terms of experience here. (21) The optimal space use factor thus becomes .75 square feet per student station hour.(22) The optimal space use standard of .75 square foot per station hour will be applied on the Duluth, Morris and St. Paul Campuses as well as the Minneapolis Campus. The conditions which warranted a different factor between Minneapolis and the other campuses in the earlier study are not assumed to be pertinent in 1975.

It should be noted that unlike the earlier study, which used total station hours, the projected student station hour teaching load on which the requirements for general purpose classrooms are calculated are non-laboratory hours only. This is reasonable inasmuch as the proportion of laboratory to lecture hours in the respective colleges is likely to change somewhat during the next 15 years.

The projected teaching load for lecture classes and the ensuing square foot requirements for general purpose classrooms are shown in Table XI.

TABLE XI: GENERAL PURPOSE CLASSROOM REQUIREMENTS FOR DAYTIME TEACHING IN 1975

Campus	Student Station Hours 1975(23)	Sq.Ft. Per SSH	Total Sq. Ft. Requirement
Duluth	71,610	.75	53,708
Minneapolis	572,034	.75	429,026
Morris	24,640	.75	18,480
St. Paul	36,099	.75	27,074

(19) Early California "Needs" Restudy
(20) Report in a panel discussion at the Wisconsin Workshop Seminar, June 1964
(21) Blakesley, op.cit.
(22) $\frac{.650(15)}{13.1} = .744$, using data for the Minneapolis Campus
(23) Excluding laboratory hours, This also ignores the relatively small number of classes offered by Minneapolis Campus departments on the St. Paul Campus

GRADUATE AND FACULTY RESEARCH

The 1956 study was based on the hypothesis that research activities would continue to be oriented toward graduate instruction and that increases or decreases in graduate enrolment would directly influence the amount of building space required for research. The number of active graduate students was therefore selected as the unit of load for the expression of research space needs.

It is recognized that since faculty members coordinate and conduct much of the research of an educational institution, research space needs could also correlate with variation in faculty size. Indeed, some institutions use this as the unit of load for projection purposes. However, since the size of the faculty is heavily influenced by anticipated graduate loads, the latter are considered to be the independent variable upon which both faculty size and research space requirements may be based.

Several observations may be made of the methodology of the original study. The space use factor for research was represented in terms of square feet of building space per graduate student enroled. This is also true of the present study. However, in 1956 the projected space needs were based only on anticipated variations in graduate attendance and no allowance was made for any inequities which may have existed in research space distribution of the base period. This had the effect of freezing any disparities which existed between colleges at that time.

The 1956 projection also ignored the possible influences of such factors as the unexpected availability of research funds in hitherto neglected fields, increased instrumentation with disproportionate increases in technical staff, introduction of new techniques, and increasing interest in post-doctoral work. It was expected, however, that adjustments would be made as appropriate following further investigation.

A follow-up study was undertaken by Willard M. Overgaard.(24) He concluded that acceptance of the fact that there are variable qualitative considerations influencing the space use factors leads to greater rationality in planning, even though the translation of qualitative influences into meaningful indices may be difficult. The present method projects total research space needs on the basis of recently compiled space use efficiency data as well as increases and decreases in anticipated graduate loads.

Another cause for concern was the disparate requirements for research space between different departments within a college due to differences in growth rates. Projecting research space needs on a collegewide basis would be reasonably reliable only if the number of active graduate students in each department increased in the same proportion. That has not been the case. Consequently, building space needs for graduate and faculty research are projected by departments rather than by colleges in this study.

(24) A Survey of Departmental Research Space Requirements, Willard M. Overgaard, October 1962, 112 pages.

The first step involved a forecast of graduate student attendance in 1975. The Office of Room Assignments and Scheduling, in cooperation with the Graduate School, had invited each teaching department in 1962 to indicate the number of graduate students which it expected to have in attendance by 1972. The resulting figures totaled 8,843 students, a very pronounced increase over the 4,400 graduate students forecast for 1970 as a part of the earlier study. Subsequently, Dean R. E. Summers indicated that graduate attendance for 1975 would approximate 13,000 students on the Minneapolis and St. Paul Campuses. The latter figure is used in this study.(25)

The next step was to identify where the students would be doing their research so that the research load could be related to a particular department. The numbers of graduate students for each department used in this study are taken from a statistical distribution developed by the Office of Room Assignments and Scheduling. (26) This does not constitute an official attendance forecast; however, the figures used are the most reliable available on which to base building space projections. That study commented on the difficulty of identifying actual physical locations where graduate study would be carried on and suggested the planning of facilities which would permit interchangability between disciplines rather than the descrete groupings characteristic of existing buildings.

Research space use factors for 1962 were then compared with the optimal space use factors used in the earlier study, and found to exceed the latter for all colleges, thus tending to confirm Professor Overgaard's findings. At this point, it was decided to delete greenhouses and farm field buildings from the building space projections. They do not represent typical buildings and make the establishment of standards more difficult. It was also concluded that if standards are inherent in optimal space use factors, the factors could be grouped into categories to facilitate planning and at the same time reflect some of the qualitative adjustments advocated by Professor Overgaard.

Seven categories of research space were selected, ranging from 10 to 500 square feet per graduate student. Every department was identified with one of the research space area categories, in each instance approximating or exceeding somewhat the average space use factor existing over the three years prior to and including 1962.(27) The relative positions and span of each category can be seen in Figure 1. Some situations may, of course, warrant special treatment. The four institutions of higher learning in Indiana have also identified research categories for the social sciences and humanities; behavioral sciences requiring laboratories; engineering and physical sciences; and life sciences. (28) However, they base their standards on numbers of faculty rather than numbers of graduate students. Allowable areas range from 10 to 600 square feet per full-time equivalent professional academic staff person, including space in greenhouses. (29)

(25) See Table I.
(26) Preliminary report, Distribution of Graduate Students, June 1964.
(27) Space use factors for 1952-1953-1954 and for 1956-1957-1958 were also averaged so as to make longer term trends discernable. Averaging helps to compensate for erratic graduate attendance and for the practical necessity of adding space in periodic rather than continuous increments.
(28) Blakesley, op.cit.
(29) Ibid.

FIGURE I: CATEGORIES OF RESEARCH SPACE

(Square Feet Per Graduate Student)

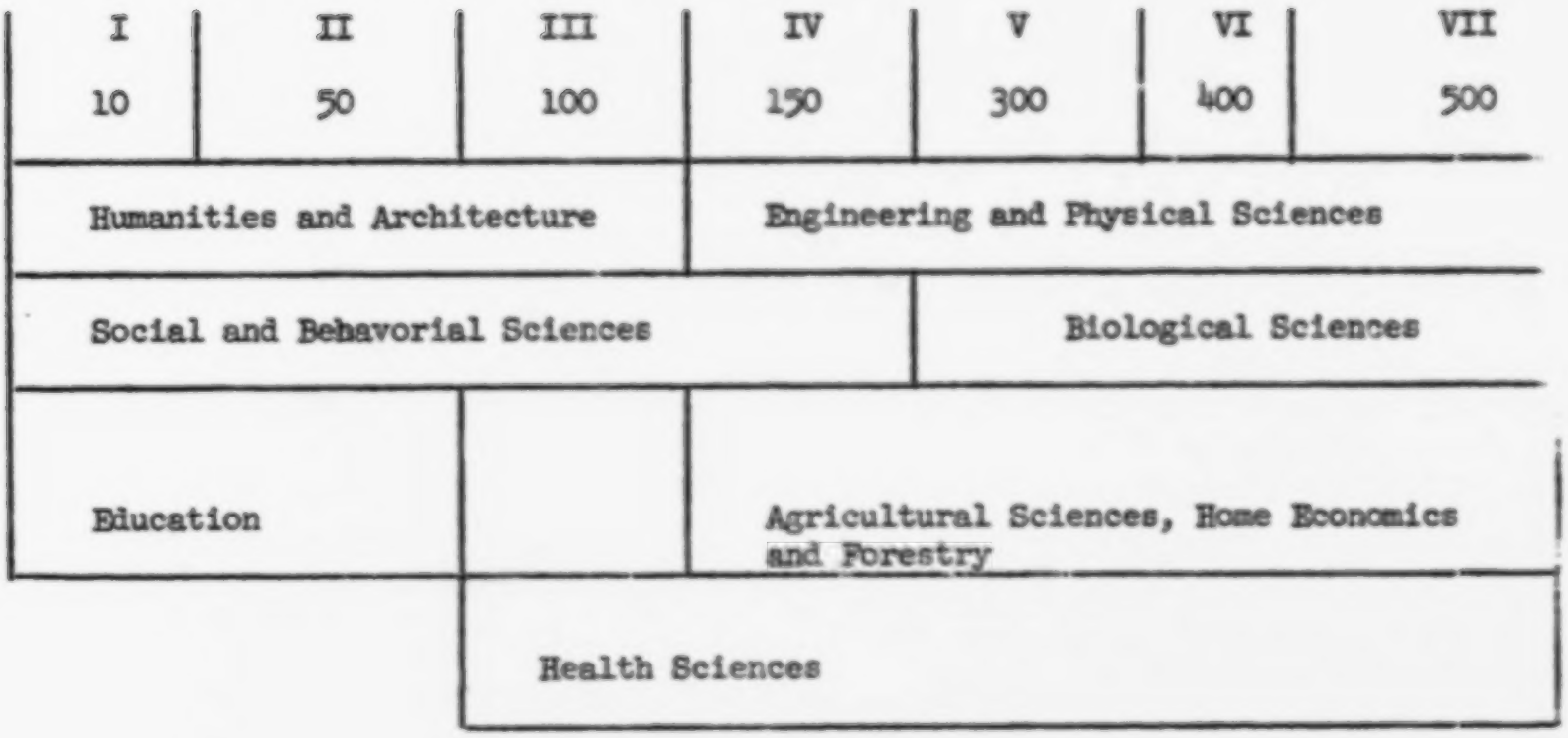

Table XII indicates research space needs of the colleges in 1975. Departments within a college fall in different research categories, depending on subject field matter rather than organizational status. Research space will average 131 square feet per graduate student in 1975 as compared with 129 square feet per student in 1962. In view of the factors discussed in preceding paragraphs which influence the amount of research space needed, this would indicate that graduate attendance is expected to increase somewhat faster in those areas which involve relatively less space for research studies.

TABLE XII: GRADUATE STUDENT-FACULTY RESEARCH REQUIREMENTS IN 1975
EXCLUDING GREENHOUSES AND FARM FIELD BUILDINGS (30)

College	Research Category	Graduate Attendance Forecast	Total Sq.Ft. Required
AFHE	III	178	17,800
	IV	89	13,350
	V	170	51,000
	VI	495	198,000
	VII	143	71,500
		1,075	351,650
Business Administration	I	952	9,520
Dentistry	V	78	23,400
Duluth	II	200	10,000
Education	I	1,662	16,620
	IV	62	9,300
		1,724	25,920
Liberal Arts	I	2,393	23,930
	II	1,656	82,800
	III	147	14,700
	V	274	82,200
	VI	28	11,200
		4,498	214,830
Medical Sciences	III	183	18,300
	IV	992	148,800
	VI	184	73,600
	VII	178	89,000
	Special	66	52,800
		1,603	382,500
Pharmacy	VI	73	29,200
Technology	I	550	5,500
	III	32	3,200
	IV	776	116,400
	V	1,205	361,500
	VI	213	85,200
	Special	104	62,400
		2,880	634,200
Veterinary Medicine	VI	117	46,800

(30) Appendix C identifies departments in each research category.

LIBRARY SERVICE

The 1956 study distinguished between rooms used for reading and rooms used for library stacks, and collection servicing. Space needs for study were seen to vary with the teaching load, whereas space needs for the collections themselves were viewed as being independent of the students served. Items in the collections continue to grow irrespective of trends in student attendance, this being the nature of library materials.

That approach is continued in this study. It might be noted that the load could be represented by number of full-time equivalent students as well as by total student station hours of instruction. The latter method avoids the necessity of ascertianing exactly what is a full-time student, and is probably the more precise measurement load.

In 1954, the space use factor for reading rooms on the Minneapolis Campus was .30 square feet per student station hour, and that figure was used for projection purposes, ignoring the crowding which already existed in study halls. The space use factor in 1962 approximated .25 square feet per station hour, and students were using stairways, corridors,and any other place where they could study. An optimal apace use factor of .40 is used in this study. This standard will provide 25 square feet for approximately one in every four students on each campus. Library needs for the Law School are projected on the basis of 1.0 square feet per station hour of instruction in that unit, and provides 30 square feet for one half of all students. This is the optimal space use factor used for that Library in the initial study. Table XIII shows projected reading room needs for 1975.

TABLE XIII: READING ROOM SPACE REQUIREMENTS IN 1975

Campus	Projected Station Hours	Sq.Ft. Per Station Hour	Total Sq. Ft. Required
Duluth	93,000	.4	37,200
Minneapolis (except Law)	664,668	.4	265,867
Morris	32,000	.4	12,800
St. Paul	61,115	.4	24,446
Law Library	15,770	1.0	15,770

The physical expansion for library resource materials and the areas which service them assumed in the initial study to be a constant 3.6 percent per year for the Minneapolis Campus. This was based on studies in the Harvard Library Bulletin for 1947 and 1948, which indicated that a mature collection doubles itself about every twenty years. The Annual Reports of the University of Minnesota Libraries reveal that total volumes in all libraries increased by 3.0 percent in 1961-62 and by 3.24 percent in 1962-63. Those figures lend credance to the annual rate of physical growth used in the projections, and that rate is again used.

The earlier study applied higher growth rates to the St. Paul and Duluth Campuses on the assumption that they were "immature" libraries whose basic collections had not yet been developed. It now seems preferable to use the annual growth rate of 3.5 percent for all campuses. This can be done by adjusting the base period figure, if necessary, and basing projections on the adjusted figure rather than on the actual area in use in 1954. The projected space needs for 1975 are as follows:

TABLE XIV: SPACE REQUIRED FOR LIBRARY STACKS AND SERVICE AREAS IN 1975

Campus	Sq.Ft. in 1954	Annual Rate of Growth	Total Sq.Ft. Required 1975
Duluth	10,122(31)	3.5 %	20,845
Minneapolis (except law)	102,668	3.5	211,434
Morris			116,000(32)
St. Paul	11,544	3.5	23,774
Law Library	15,446	3.5	31,809

PUBLIC SERVICE

Service to the State of Minnesota through avenues other than research and resident instruction is an important function of the University. There are many facets to public service. It is expressed in what is commonly termed "extension" work, including such activities as continuation or short courses, county and home agent services throughout the State, and evening and correspondence classes. It is seen in various cultural activities in which the public is encouraged to participate; among these are radio broadcasting, the art galleries, the museum on the Minneapolis Campus, and a wide variety of programs, play productions and concerts on the four campuses. Finally, it is available in special professional services such as school surveys, soil testing, ore tax estimating, storage of state archaeological material, geological surveys, educational testing, etc. Many clinical services are also available as an adjunct to instruction.

The earlier study observed that space needs for public service have little or no relationship to student attendance at the University.(33) For want of a better load measurement, expansion was related to the population of the State. However, public service by the University is influenced by the demand for such services and funds available for their support. Inasmuch as the public services are largely self-supporting through revenues, private gifts or special federal and state appropriations, they can in the last analysis be viewed as a response to demand by the public. This being the case, future space needs can be extrapolated on the basis of historical expansion trends which reflect past demands for the services. This seems to be a more logical approach than to base expansion on population forecasts, and will be used in this study.

(31) Adjusted from 5,061 square feet in the 1956 study; see Middlebrook, P.33.
(32) Figure used by Morris Campus Planning Committee in 1964.
(33) See Middlebrook, page 39.

Many of the public services described are a responsibility of the Vice President for Academic Administration, or involve general purpose facilities and are scheduled centrally. The colleges having significant amounts of Public space are the Institute of Agriculture, the University of Minnesota at Duluth, the General Extension Division, and the College of Liberal Arts. Figures for the other colleges have been combined for purpose of analysis.

During the eight years between 1954 and 1962 assignable space devoted to public service increased only 11,905 square feet. The increases varied considerably between the various organizational units, as can be seen from the summary in Table XV. During this time the Geology Museum and most of the Anthropology Museum were converted to graduate and faculty research, and the museum materials removed from public display to storage. Also, the auditorium in the Museum of Natural History, once used extensively for continuation courses, became a classroom during daytime hours.

TABLE XV; INCREASE IN SPACE USED FOR PUBLIC SERVICE BETWEEN 1954 AND 1962

Unit	1954	1962	Increases
Institute of Agriculture	15,794	23,304	47.5
U of M at Duluth	9,402	12,304	30.9
General Extension Division	22,530	23,537	4.5
College of Liberal Arts	8,619	9,303	7.9
Other colleges	11,876	11,235	-5.4
Vice Pres.-Academic Admin.(34)	34,302	39,032	13.8
General Purpose Rooms (35)	54,290	50,003	-7.9

The 1956 forecast of 1970 population in Minnesota represented an increase of slightly more than one percent each year beginning in 1939. A one percent increase in public service space, compounded annually from 1954, would bring total public service space to 169,797 assignable square feet by 1962, very close to the 168,718 square feet reported for that year. Many units, however, expanded their service work considerably during that time without any appreciable increase in space and need more room if they are to continue doing an effective job.

It seems appropriate to use the compound interest formula for projecting Public Service space needs inasmuch as each expansion in operations creates a larger base for successive expansions generated by public demand for the services. Using a compound interest table, one will obtain the following building areas in 1975, depending on what rate of growth is applied to the 1962 base period:

one percent	192,001 square feet
one and one-half percent	204,739 square feet
two percent	218,254 square feet
two and one half percent	232,578 square feet
three percent	247,762 square feet

(34) Including the Museum's research activity.
(35) Auditoriums and meeting rooms, including that in the Main Building on the old Campus at Duluth.

The figure of two and one half percent increase each year is used in this study. This will provide approximately 40,000 more square feet by 1975 than would the formula used in the earlier study, and seems conservative in view of the existing conditions. This would not include the proposed auditoriums on the Duluth and Morris Campuses, or the likelihood of a new auditorium on the St. Paul Campus. Table XVI summarizes projected space needs for Public Service, keeping the latter facilities in mind.

TABLE XVI: PUBLIC SERVICE SPACE NEEDS IN 1975

	Square feet
Total for all Campuses	232,578 (36)
Auditorium, Duluth Campus	39,000 (37)
Auditorium, Morris Campus	18,750 (38)
Auditorium, St. Paul Campus	39,000

ADMINISTRATION AND STUDENT SERVICE

The initial study of future University space needs projected student service areas in the colleges on the basis of the student station hour load but used total number of students in projecting space needs for central departments such as, for example, the Office of the Dean of Students, the Student Health Service and the Department of Student Unions. It was thought then that the load occasioned in counseling and professional services would vary somewhat depending on whether or not students were carrying full academic loads. That reasoning seems less compelling now, and this study is projecting all student service needs on the basis of the total number of students in attendance.

In projecting space needs for administrative purposes, the earlier study used the number of students in attendance in identifying the load to be served. That load measurement is also used in this study. However, the distinctions between academic programming and business management are ignored since they were not particularly meaningful.

Inasmuch as the same load is used as a basis for projecting administrative and student service space needs, the two kinds of areas are combined in this study on the college level. The facilities in practice have been closely interrelated, and there is no observable value in projecting college adminstrative space needs independently of those required for counseling and placement activities.

The optimal space use factors for the various major organizational units are shown in Table XVII. That table also identifies the space use factor existing in 1954, the base period used in the initial study, and in 1962. A few items need some explanation. The 1962 space use factor for

(36) Based on 1962 areas compounded annually at $2\frac{1}{2}$ percent.
(37) Based on Legislative request for funds to match gigts.
(38) Figure used by Morris Campus Planning Committee in 1964.

the Law School includes lounge facilities. Inasmuch as the facility was sanctioned by the Advisory Committee on Space Allocation only to the extent that the basement area was not required for other purposes, that area should not affect the optimal space use factor for 1975. The 1954 space use factor for the College of Liberal Arts did include areas related to the University Theatre which are now classified as instructional. However, the 1962 space use factor was abnormally low and accompanied the decentralization of administration in that college. Moreover, that college is now emphasizing a placement service which was a minor consideration in 1962. It seemed appropriate, therefore, that the optimal space use factor approximate the 1954 factor. The Duluth and Morris Campuses figures reflect activities which on the St. Paul and Minneapolis Campuses are viewed as central administration. Selection of optimal space use factors for projection purposes necessarily involve subjective or judgemental evaluations of historical space use factors in light of new educational developments and directions.

TABLE XVII: COMPARISON OF SPACE USE FACTORS FOR ADMINISTRATION AND STUDENT SERVICE

	Space Use Factor In(39) 1954	1962	Optimal Space Use Factor
Administration and Student Service			
Agriculture	6.58	5.33	6.0
Business Administration	5.56	7.55	6.0
Dentistry	5.69	5.51	5.5
Education	2.60	2.66	3.0
General	1.63	.92	2.0
Graduate	2.33	1.08	2.0
Law	5.04	10.27	5.0
Liberal Arts	2.76	.94	2.5
Medical Sciences	1.61	2.39	3.0
Pharmacy	7.02	7.30	6.0
Technology	3.21	3.12	3.2
Veterinary Medicine	10.10	14.09	6.0
Administration			
Duluth	2.57	8.84	7.0
Morris		7.61	7.0
Office of the President	.17	.09	.20
Academic Administration	1.20	.14	.25
Educational Relationships		.77	1.25
Business Administration	2.15	2.24	2.50
Student Service			
Duluth	5.01	6.38	7.50
Morris		1.08	7.50
Academic Administration	7.48	2.16	2.25
Educational Relationships		4.80	5.25

(39) See page 6 for discussion of space use factors

Table XVIII identifies the total space needs for administration and student services. It utilizes the optimal space use factors shown in the previous table, which are applied to the number of students served. In the case of the President's Office, the factor was applied to the total University attendance projected for 1975. The projections for the offices of the three Vice Presidents relate to total graduate, undergraduate, and professional attendance on the St. Paul and Minneapolis Campuses only. This is because many of the functions of those offices are performed within the administrative units of the Duluth and Morris Campuses, and are reflected in the optimal space use factors for those campuses. Graduate students are not included with the colleges where the students do their work because registration and most other administrative responsibilities for such students are handled in the Graduate School which has its own space use factor.

TABLE XVIII: ADMINISTRATIVE AND STUDENT SERVICE SPACE REQUIREMENTS IN 1975

College or Administrative Unit	Number of Students(40)	Sq.Ft.Per Student(41)	Total Area (Sq.Ft.)
Agriculture	3,500	6.0	21,000
Business Administration	1,000	6.0	6,000
Dentistry	550	5.5	3,025
Duluth	6,000	14.5	87,000
Education	4,700	3.0	14,100
General	4,250	2.0	8,500
Graduate	13,200	2.0	26,400
Law	1,050	5.0	5,250
Liberal Arts & Univ. College	16,450	2.5	41,125
Medical Sciences	1,600	3.0	4,800
Morris	2,000	14.5	29,000
Pharmacy	400	6.0	2,400
Technology	6,000	3.2	19,200
Veterinary Medicine	300	6.0	1,800
Central Administration:			
President	61,750	.20	12,350
Academic Administration	53,000	2.50	132,500
Educational Relationships	53,000	6.50	344,500
Business Administration	53,000	2.50	132,500

PHYSICAL EDUCATION

Physical Education includes space used for physical education instruction, intramural sports, and intercollegiate athletics. In the earlier study, student station hours were used to measure the load for two reasons: (1) the facilities are used for teaching, and (2) students with less than a minimum number of credits were not eligible to use many intramural facilities. That measure also weights the load in favor of undergraduate students who are more likely to use intramural facilities than are graduate students. Station hours are used as the measure of load in this study as well.

(40) See Table I.
(41) See Table XVII.

The classification of physical education facilities in the 1956 study into offices, activity areas, equipment rooms, and service rooms made it possible to differentiate between areas which must increase in a direct ratio with the load, and those which would increase at a lesser rate because of efficiencies seen in increased numbers. There is little evidence to indicate that this approach is particularly meaningful, however, and it was decided to discontinue any differentiation between one kind of physical education facility and another.

The Duluth Campus in 1954 had 1.31 square feet of physical education space per station hour of teaching. The figure 1.30 was used by the Morris Campus Planning Committee. Calculations give a figure of 1.22 for the combined Minneapolis-St. Paul Campuses in 1954 when Williams Arena and the Field House are included. In view of this, a figure of 1.3 square feet per station hour for projecting physical education space needs appears sound. The 1975 space needs for Physical Education are calculated in Table XIX.

TABLE XIX: PHYSICAL EDUCATION SPACE REQUIRED BY 1975

Campus	Student Station Hours in 1975	Sq.Ft.Per SSH	Total Sq.Ft. Required
Duluth	93,000	1.3	120,900
Minneapolis-St. Paul	741,553	1.3	964,019
Morris	32,000	1.3	41,600

INSTITUTIONAL SERVICE

The function Institutional Service encompasses a wide variety of central services, operation of the laboratory schools in the College of Education and the hospitals in the College of Medical Sciences, housing and food service. This study does not cover space needs of the laboratory schools, hospitals or residence halls.

Internal services comprise those services available to all colleges and administrative or service departments of the University. While most internal services are operated through the Office of the Vice President for Business Administration, some are attached to an academic unit. The numerical Analysis Center is an example of the latter. Internal services include such units as central storehouses of the Business Office, bookstores, printing, laundry service, central shops serving the teaching and research activities, transportation, etc. They are for the most part self-supporting.

The earlier study related the load for some internal services to student station hours of instruction, but most loads were measured in terms of student attendance. Both methods can be argued for particular situations. Since the resulting projections are sufficiently reliable for planning purposes, student attendance is used as the measurement of load in this study rather than station hours.

Experience since 1956 has shown that expansion of the internal service units tend by and large to correlate with increases in number of students. Consequently, the assumption made at that time that most areas would increase more slowly than attendance due to increasing efficiences cannot be substantiated. This study assumes that space needs for internal services will increase in direct proportion to increases in attendance, and that the space use factor in 1962 can be accepted as the optimal space use factor. The rather extensive detailing of internal services in the earlier study has been discontinued in favor of more general groupings such as were used for instruction and research.

Food Service includes only cafeterias and lunch counters open to all students, and no dining rooms and kitchens located in residence halls. The category is intended also to include eating facilities for students who bring bag lunches. There were no such facilities in 1954, excepting the North Star Room in Coffman Memorial Union.

In 1954, there were 3.5 square feet of space devoted to Food Service on the Minneapolis Campus.(42) By 1962 that figure was down to 2.5 square feet, not counting the North Star Room. At the same time, it was 2.4 and 5.0 square feet respectively per student on the Duluth and Morris Campuses. The above space use factors do not account for bag lunch facilities, such as the North Star Room in the Union.

The earlier study concluded that the Minneapolis Campus would need food facilities for 30 percent of its student body in the future; the remaining students would eat at home, in residence hall dining rooms or in private establishments.(43) It was expected that two out of five students within the 30 percent group would be using bag lunch facilities by 1970. That study also observed that cefeteria facilities were adequate on the Duluth Campus to accommodate up to 4,132 students, but that bag lunch facilities needed to be increased. Food facilities on the St. Paul Campus were inadequate at the time, but a new Dining Center has since been built. That building serves dormitory residents on a contractual basis as well as the rest of the campus, thus introducing a new element into the projections.

There is need for further study of this category before a sound projection of future space needs can be made. However, it seems desirable to give some recognition to space needs for bag lunches pending further study, since this is now an important new consideration somewhat independent of cafeteria space. A figure of .5 square feet per student has been selected for this purpose,(44) and is applied to all campuses except the University of Minnesota at Morris. Most students at that campus are expected to be living in residence halls. Table XX shows projected space needs for Institutional Service in 1975.

(42) The dining room in the Continuation Center is not included in the space use factors discussed here.
(43) Middlebrook, page 82
(44) It might be noted that the bag lunch area in the North Star Room of the Union amounted to .4 square feet per student on that campus in 1954.

TABLE XX: INSTITUTIONAL SERVICE SPACE REQUIREMENTS IN 1975

	Sq.Ft.in 1962	Sq.Ft.Per Student	Attendance 1975	Total Sq.Ft. Required
Internal Service				
Central Administration	296,248	10.1	52,800	533,280
U of M at Duluth	11,788	3.7	6,200	22,940
U of M a Morris	755	1.5	2,000	3,000
Other Colleges	14,101	.5	52,800	26,400
General Purpose	30,628	1.0	52,800	52,800
Food Service(45)				
U of M at Duluth		.5	6,200	3,100
Minneapolis Campus		.5	47,808	23,904
St. Paul Campus		.5	4,992	2,496

PLANT OPERATION

Plant Operation includes areas used for custodial service, building maintenance, and maintenance of grounds, roads and field plots. Shops involved with maintenance and repair are in this category, but production shops are classed as Internal Service. The assumption was made in the earlier study that future space requirements for Plant Operation would represent the same proportion of total physical plant area as they did in 1954.

Table XXI shows Plant Operation areas and space use factors for 1954 and 1962. Plant Operation space for the Duluth Campus during that period did not keep up with increases in total physical plant area. However,

TABLE XXI: COMPARISON OF SPACE USE FACTORS FOR PLANT OPERATION

Campus	Sq.Ft. Plant Operation 1954	Sq.Ft. Plant Operation 1962	Space Use Factor (46) 1954	Space Use Factor (46) 1962
Duluth	9,919	16,893	54.2	44.7
Minneapolis(47)	67,626	87,404	24.5	26.5
Morris		3,915		58.6
St. Paul	39,400	48,388	63.4	63.7
Grounds only		24,226		31.9
St. Paul (excel. grounds) and Minneapolis		111,566		27.5

(45) This projection relates to bag lunch facilities only.

(46) Calculated from data in Report on Building Space Assignments and Use, University of Minnesota, May 10, 1963, Office of Room Assignments and Scheduling. Field buildings and greenhouses are excluded from the total physical plant areas on which the space use factors are based.

(47) Includes 8, 141 square feet in Mayo Memorial; however, the space use factors do not cover building areas used by University Hospitals.

the space use factors for the Minneapolis and St. Paul Campuses showed no appreciable change between 1954 and 1962. This tends to substantiate the assumption that the proportionate relationship existing between the two areas in the base period will continue without appreciable change. Facilities at the Duluth Campus in 1962 did fall short of providing adequately for plant maintenance, and the University is seeking to improve that situation.

Two considerations prompt a change in the method of using space use factors for Plant Operation. First, half of those areas on the St. Paul Campus were used to maintain fields and grounds in 1962, a situation not typical on other campuses.(48) Expansion of the physical plant in terms of buildings would seem to have minimal direct effect on field and grounds maintenance. Existing campus boundaries are also likely to become permanent. For these reasons, no space projections are made in this study for field and grounds maintenance for the St. Paul Campus. Secondly, much Plant Operation activity is now housed on Como Avenue midway between the two campuses. These buildings are included in the projections with those for the Minneapolis Campus, but they increasingly serve the St. Paul Campus as well. It seemed logical, therefore, to make a combined projection of future Plant Operation space needs for those Campuses. The figure of 27.5 square feet for every one thousand assignable feet of total physical plant, which was the combined space use factor in 1962 for the Minneapolis and St. Paul Campuses, is used in this study.

A comparable figure of 50 square feet is used for the Duluth and Morris Campuses. The initial study observed that larger campuses permit more efficient use of facilities. This applies to equipment as well as building space. The fact that residence halls are not included in total physical plant areas may make the optimal space use factors too conservative if the proportion of residence hall to total physical plant areas increases significantly.

TABLE XXII indicates building areas required in 1975 for Plant Operation.

TABLE XXII: PLANT OPERATION SPACE REQUIRED BY 1975

Campus	Total Building Area Without Plant Operation(49)	Plant Operation Area Per Each 1,000 Sq.Ft.	Total Sq.Ft. Required
	(All areas assignable square feet)		
Duluth	625,661	50.0	31,283
Morris	206,762	50.0	10,338
Minneapolis-St.Paul	7,446,931	27.5	204,790

(48) The North Central Experiment Station maintains grounds for the University of Minnesota at Morris in addition to its own grounds and fields.

(49) See Table XXIV

PROJECTION RESULTS

The projection of building space needs for 1975 is summarized in Table XXIII. Total additional building space needs on the four campuses are revealed as being 3,934,000 square feet more than the comparable area available in 1962. This represents an increase of 85.2 percent. Student attendance forecasts, exclusive of Mayo fellows, show an increase of 85.0 percent over the same period of time. It is an interesting coincidence that the two figures should be nearly identical. Many different load measurements and optimal space use factors were involved in the projections, and any inference that attendance alone is a valid indication of future building space needs is unwarranted.

TABLE XXIII: SUMMARY OF ADDITIONAL BUILDING SPACE NEEDS BY 1975

	Building Areas 1962	Projected Needs 1975	Additional Space Required
	(All areas assignable square feet)		
Faculty Offices		627,505	
Teaching Laboratories		614,133	
Clinical Laboratories		57,000	
Teaching Service		658,262	
General Classrooms		528,288	
Instruction	1,604,965	2,485,188	880,223
Research	700,475	1,728,020	1,027,545
Reading Rooms		356,083	
Stacks and Service		303,862	
Library Service	349,007	659,945	310,938
Public Service	168,718	329,328	160,610
Administration and Student Service	403,237	891,450	488,213
Physical Education	488,027	1,126,519	638,492
Institutional Service	353,540	667,920	314,380
Areas not projected(50)	390,984	390,984	
	4,458,953	8,279,354	
Plant Operation	156,600	270,637(51)	114,037
	4,615,553	8,549,991	3,934,438

(50) This item includes the laboratory schools, Flight Facilities at the Anoka Airport, ROTC units, unassigned space (except old campus at Duluth), departmental libraries, cafeterias and outside organizations and government agencies. The study does not cover residence halls, farm field buildings and greenhouses, or the University Hospitals.

(51) See Table XXII, also includes 24,226 square feet of space for maintenance of grounds and farm fields, for which no projection was made.

Projected building areas for 1975 were distributed between the four campuses to ascertain what additional space will be needed on each campus if major units remain where they are now and space assigned to central administration units continues to be apportioned between the Minneapolis and St. Paul Campuses as it was in 1962. Table XXIV indicates the extent of the additional requirements for each campus. The sum total of additional needs on the four campuses will require 79 buildings the size of Ford Hall by 1975.

TABLE XXIV: DISTRIBUTION OF PROJECTED 1975 BUILDING SPACE REQUIREMENTS BY CAMPUS

	Duluth	Minneapolis	Morris	St. Paul
Instruction	234,202	1,786,145	80,586	384,255
Research	10,000	1,319,570	(52)	398,450
Library Service	58,045	524,880	28,800	48,220
Public Service	56,443	161,642	21,076	90,167
Administration and Student Service (54)	87,000	659,372	29,000	116,078
Physical Education (55)	120,900	877,257	41,600	86,762
Internal Service (56)	26,040	605,760	3,000	33,120
Areas not projected (57)	33,031	267,378	2,700	87,875
	625,661	6,202,004	206,762	1,244,927
Plant Operation	31,283	157,688	10,338	71,328 (58)
Total Area	656,944	6,359,692	217,100	1,316,255
Area in 1962	358,905	3,388,384	70,585	797,679
Additional Area Req'd	298,039	2,971,308	146,515	518,576
% Increase	83.0	87.7	207.6	65.0

(52) The Morris Campus Planning Committee projected 2,900 square feet for research.

(53) The 232,578 square feet projected for all campuses (See Table XVI) were distributed according to the proportion each campus had of total Public Service space in 1962.

(54) The 621,850 square feet of Administration and Student Service space projected for the central administration (Table XVIII) were distributed between the Minneapolis and St. Paul Campuses according to the proportionate comparable areas each had in 1962.

(55) The 964,019 square feet of Physical Education space projected for the Minneapolis-St. Paul Campuses (Table XIX) were distributed according to the proportionate share of each campus in 1962.

(56) The 612,480 square feet of Internal Service projected for the central administration and colleges on the Minneapolis and St. Paul Campuses (Table XX) were distributed according to the proportionate share of each campus in 1962.

(57) See footnote 51.

(58) Includes 24,226 square feet of space for maintenance of grounds and farm fields, for which no projection was made.

In the earlier study, there was a comparison for the Minneapolis Campus of assignable square feet of space per student for each category of space use in 1954 and 1970, the latter being the year to which projections were made.(59) Table XXV shows how the projections in this study compare with the earlier figures. Differences would be expected inasmuch as the comparison is between data for all campuses in 1975 and data for the Minneapolis Campus only in the earlier years. Nevertheless, some of the figures reflect the impact of a much larger proportion of graduate students attending the University, as in the decrease of instructional areas and the increase of research areas per student, for example.

TABLE XXV: ASSIGNABLE AREAS PER STUDENT

Function	Minneapolis Campus Actual 1954	Minneapolis Campus Projected 1970 (60)	All Campuses Projected 1975 (61)
Instruction and Library Service	79.3	61.0	51.5
Research	20.2	14.9	28.3
Public Service	6.6	3.3	5.4
Administration & Student Service	35.4	23.9	14.6
Physical Education	23.0	15.1	18.5
Internal Services	17.6	11.0	10.9
Plant Operation	4.2	2.9	4.4
All Other	5.7	2.5	6.4
	192.0	134.6	140.0

The data in Table XXV applies to the total student body, and has no practical applications. Instructional and Library Service for 1962 represented 69.9 square feet per undergraduate student on all campuses, whereas the comparable figure in 1975 is 65.8 square feet. Likewise, Research space in 1962 represented 129 square feet per graduate student on all campuses as compared with 131 square feet in 1975. This is quite a different picture from that suggested by the figures in Table XXV, and indicates the importance of using data within their proper context.

IMPROVEMENT OF PROJECTION METHODS

There have been many refinements in the original methods developed to estimate long-range building needs. In certain instances, the methods have been modified by a somewhat different approach. These changes have evolved through experience. The procedures used in this study project future space needs more realistically and more precisely than the methods previously employed. Nevertheless, several aspects of the procedure should be given further study.

Inasmuch as the space use studies assume the existence of accurate attendance forecasts, the methods used to obtain such figures are not considered here. However, no office has responsibility for estimating the distribution of graduate students between departments. The distribution used in this study

(59) Middlebrook, page 61. Data for Physical Education has been added.
(60) This was the 1956 study.
(61) Based on the study.

was made by the Office of Room Assignments and Scheduling only because the distribution has a major impact on research space requirements where the methods outlined in this study are followed in projecting research space needs. It has subsequent implications in the design, planning, and location of specific buildings. Therefore, it is important that the distribution of forecasted graduate attendance be as accurate as possible.

Space needs for graduate and faculty research are based on area per graduate student as in the initial study. Both graduate students and faculty persons, however, require varying amounts of space for research studies, and the figure used represents an overall average. It is appropriate now to consider whether or not graduate students not normally involved in research work, such as Plan B students, should be included in the number on which the space forecasts are based. It is possible that graduate students concerned primarily with course work rather than thesis research should be treated so that their changing proportions would not distort the space needs projected for research facilities. Data on course work of thesis research graduate attendance is not avialable in a workable, investigable form at this time. The Graduate School is now attempting to record its graduate student information on punched cards in a way that the necessary information can be more readily retrieved.

It will be recalled that teaching laboratory space needs were based on square foot per laboratory student station hour. In this study, the proportion of projected laboratory hours to total projected student station hours are the same in 1975 as they were for 1962. It may not necessarily follow, however, that this trend will continue in actual practice. Students crossing over from one college may take primarily lecture courses or primarily laboratory courses in the second college. The data in Table II on page 4, which indicates the hours per week that a student spends in the classrooms and laboratories of each instructional unit, should perhaps comprise two tables, one relating to laboratories and one relating to lecture rooms.

The desirability of continuing study of the optimal space use factors used in this study has been noted repeatedly in the preceding paragraphs. However, given optimal space factors, attendance forecasts, and various postulates concerning use of space, a projection of building space needs has ensued from the study. The question then arises: Would it not be possible to develop a computer program based on projection methods and factors so that building space needs can be projected readily for any given attendance configuration and graduate student distribution? The methods discussed could then become a practical tool in planning and administration.

APPENDIX A: DISTRIBUTION OF GRADUATE STUDENTS*

Department of Students' Major Field	Number of Graduate Students In Attendance 1962	Projected 1975
Aeronautics	59	154
Agricultural Economics	74	178
Agricultural Education	30	69
Agricultural Engineering	13	31
Agronomy	66	114
American Studies	82	205
Anatomy	29	56
Anesthesiology	28	62
Animal Husbandry	21	44
Anthropology	24	76
Architecture	7	32
Art	29	71
Art Education	18	42
Astronomy	0	3
Biochemistry (Agric)	43	96
Biochemistry (Med)	50	111
Biophysics	5	28
Botany	31	114
Business Administration	284	875
Chemical Engineering	82	170
Chemistry	166	436
Child Development	35	62
Civil Engineering	79	213
Classics	12	34
Comparitive Literature	9	23
Dairy Husbandry	28	46
Dairy Industries	18	42
Dentistry	27	78
Earth Sciences (Geology)	51	110
Economics	109	260
Electrical Engineering	182	496
English	220	536
Entomology	47	85
Foreign Areas	11	35
Forestry	43	89
General Education	704	1436
Geography	34	88
German	43	118
History	163	411
Home Economics	39	85
Home Economics Education	7	45
Horticulture	18	40
Industrial Education	30	63
Industrial Relations	28	77
International Relations	21	42

Department of Students' Major Field	Number of Graduate Students In Attendance 1962	Projected 197
Journalism	50	129
Laboratory Medicine	4	38
Library	101	265
Linguistics	1	5
Mathematics	199	550
Mechanical Engineering	109	271
Medicine	82	184
Microbiology	38	73
Mineral & Metallurgical Engineering	39	104
Music	39	90
Music Education	10	33
Nursing	1	2
Obstetrics	13	30
Opthalmology	15	31
Otolaryngology	9	21
Pathology	33	64
Pediatrics	38	103
Pharmaceutical Chemistry	18	43
Pharmaceutical Technology	5	24
Pharmacognosy	1	6
Pharmacology	27	58
Philosophy	50	90
Physical Education	20	52
Physical Medicine	10	29
Physics	138	341
Physiology	28	66
Plant Pathology	60	102
Political Science	146	307
Poultry Husbandry	13	26
Psychiatry	53	115
Psychology	217	393
Public Health	54	183
Radiology	35	66
Romance Languages	47	128
Scandinavian	2	14
Sociology	56	206
Soils	28	52
Speech-Theatre Arts	109	275
Statistics	34	99
Surgery	156	311
Social Work	100	263
Veterinary Medicine	58	117
Zoology	63	160

* Based on preliminary report, Distribution of Graduate Students, prepared by the Office of Room Assignments and Scheduling in June, 1964 with cooperation of other offices.

CALCULATION OF PROJECTION STANDARDS FOR TEACHING LABORATORIES

College	Available Station Hours-1962*	Standard Utilization+	Optimal Station Hour Load	Teaching Lab Areas-1962 (Sq.Ft.)	Sq.Ft.Per Optimal Station Hour	Projection Standard Used (Sq.Ft./SSHour)
AFHE	77,080	24 %	18,499	92,907	5.02	5.0
Business Administration	2,332	56	1,306	1,167	.89	1.0
Dentistry	13,800	30	4,140	10,575	2.55	2.6
Duluth	49,520	40	19,808	59,892	3.02	3.1
Education	19,360	40	7,744	18,430	2.38	2.5
General	3,000	60	1,800	4,172	2.32	2.4
Liberal Arts	73,480	40	29,392	77,088	2.62	2.7
Medical Sciences		24		38,038	#	3.5
Morris	20,000	40	8,000	12,133	1.52	3.1
Pharmacy	10,680	24	2,563	11,600	4.53	4.5
Technology	112,120	30	33,636	190,862	5.67	5.7
Veterinary Medicine	18,840	24	4,522	15,667	3.46	3.5

* Based on forty hour week.
\+ Derived from Table VII, page 10, allowing 80 percent filling.
\# Data not available for laboratories in the Mayo Memorial; optimal space use factor in 1956 study was 3.41 square feet per student station hour.

APPENDIX C: DEPARTMENTS INCLUDED IN VARIOUS RESEARCH CATEGORIES FOR PURPOSES OF PROJECTING BUILDING SPACE NEEDS

Category	Department or Field	
I	Agricultural Education	Library School
	American Studies	Linguistics
	Art Education	Mathematics
	Business Administration	Music
	Classics	Music Education
	Comparative Literature	Philosophy
	English	Physical Education
	Foreign Area Studies	Political Science
	General Education	Romance Languages
	German	Scandinavian
	History	Special Education
	Industrial Education	Statistics
II	Economics	Psychology
	Geography	Social Work
	International Relations	Sociology
	Journalism	Speech & Theatre Arts
III	Agricultural Economics	Art
	Anthropology	Public Health
	Architecture	
IV	Anethesiology	Obstetrics
	Chemical Engineering	Ophthalmology
	Child Development	Otolaryngology
	Earth Sciences (Geology)	Pediatrics
	Electrical Engineering	Physical Medicine
	Forestry	Psychiatry
	Laboratory Medicine	Radiology
	Medicine	Surgery
	Nursing	
V	Aeronautics	Home Economics Education
	Astronomy	Horticulture
	Botany	Mechanical Engineering
	Chemistry	Physics
	Dentistry	Zoology
	Home Economics	
VI	Agronomy	Entomology
	Biochemistry (Agric)	Microbiology
	Biochemistry (Med)	Pharmacy
	Biophysics	Plant Pathology
	Civil Engineering	Soil Science
	Dairy Husbandry	Veterinary Medicine
VII	Agricultural Engineering	Pathology
	Anatomy	Pharmacology
	Animal Husbandry	Poultry Science
	Dairy Industries	
Special	Mining & Metallurgical Engineering	Physiology